SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE STATIC ATOM[1]

I HAVE been asked to present in this symposium the relation between atomic structure and the "valence bonds" by which the atoms are regarded as tied together, to form the more complicated structure of the molecule. Now the whole theory of molecular constitution which I have developed rests upon the fundamental postulate that the atom is internally at rest or nearly so. On the other hand, Bohr, who has given special attention to the phenomena of spectral series, has been led to the view that the electrons in the atom are revolving rapidly about a central positive nucleus. Because of the wide acceptance by physicists of Bohr's theory of the atom and its orbital electrons, and especially in view of the very lucid arguments in favor of this theory which Professor Millikan has just presented to us, I am going to ask your permission to modify the subject of my paper, and to discuss not the specific methods of combination among the atoms, but rather the question as to whether the electrons in the atom and the molecule are in rapid motion or are essentially at rest; for upon our answer to this question any theory of molecular structure must depend.

Now assuming that the electron plays some kind of essential rôle in the linking together of the atoms within the molecule, and, as far as I am aware, no one conversant with the main facts of chemistry

[1] Presented at the symposium on "The Structure of Matter" at a joint meeting of the Sections of Physics and Chemistry of the American Association for the Advancement of Science, The American Physical Society and the American Chemical Society, New York, December 27, 1916.

would deny the validity of this assumption, let us consider the typical compounds of old-fashioned organic chemistry in regard to whose molecular structure we already know much—at the very least we may speak definitely of the relative positions of the atoms within their molecules. Among such compounds we find the striking phenomenon of isomerism. Numerous isomers, substances of precisely the same chemical constituents and differing only in the relative order in which the atoms are placed in the molecule, have been prepared. In the case of complex substances, if it were worth while, millions of such isomers could be prepared. Yet these isomers will keep for years, and probably would for centuries, without changing into one another. In these inert organic compounds the atoms are so persistently retained in definite positions in the molecule that in one part of the molecule atoms may be substituted for other atoms and groups for groups, sometimes through reactions of great violence, without disturbing the arrangement of the atoms in some other part of the molecule. It seems inconceivable that electrons which have any part in determining the structure of such a molecule could possess proper motion, whether orbital or chaotic, of any appreciable amplitude. We must assume rather that these electrons are held in the atom in fixed equilibrium positions, about which they may experience minute oscillations under the influence of high temperature or electric discharge, but from which they can not depart very far without altering the structure of any molecule in which the atom is held.

Let us therefore consider whether the physicists on their part offer any irrefutable arguments in favor of an atomic model of the type of Bohr's. In an atom of the simplest type, composed of a single positive particle and a single electron, if these fail to merge with one another until their centers are coincident—and it is universally assumed that they do not so merge—only two explanations are possible: either the ordinary law of attraction between unlike charges (Coulomb's law) ceases to be valid at very small distances, or the electron must be in sufficiently rapid motion about the atom to offset the force of electric attraction. The first of these explanations is the one which I have adopted. The second, which has been adopted largely because it appears to save Coulomb's law, is the one which has led to Bohr's atomic model, in which the electron revolves in definite orbits about the central positive particle. Now it has frequently been pointed out, and indeed it was well recognized by Bohr himself, that this model is not consistent with the established principles of the electromagnetic theory, since in the classical theory a charged particle subjected to any kind of acceleration must radiate energy, while, according to the Bohr hypothesis, radiation occurs only when an electron falls from one stable orbit into another. Since, however, the equation for electromagnetic radiation is one of the more abstruse and less immediate deductions of the classical theory, it might be possible by slight modifications of the fundamental electromagnetic equations to reconcile them with the non-radiation of the orbital electron. I wish therefore to point out a far more fundamental objection to the theory of the revolving electron, due to the fact that Bohr has been forced to assume that this revolution must continue even down to the absolute zero of temperature.[2]

If, in Fig. 1, the circle represents the orbit of an electron B revolving about the positive center A, and if C represents a charged particle in the neighborhood, then if the electron exerts any influence what-

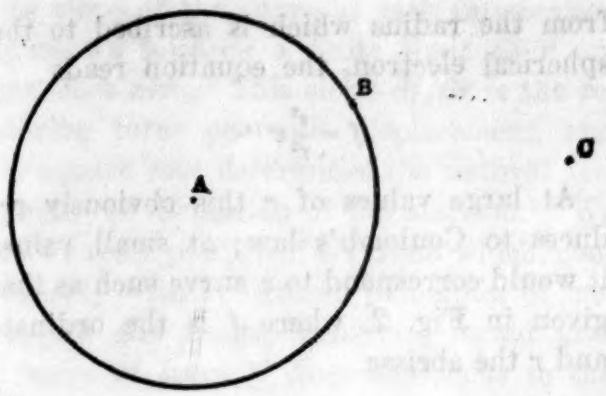

FIG. 1.

soever upon the particle *C*, the latter will be set into sympathetic motion, and a part of the energy of the *atom at the absolute zero* will be contributed to the particle *C*, contrary to the most fundamental principles of thermodynamics. Therefore, unless we are willing, under the onslaught of quantum theories, to throw overboard all of the basic principles of physical science, we must conclude that the electron in the Bohr atom not only ceases to obey Coulomb's law, but exerts no influence whatsoever upon another charged particle at any distance. Yet it is on the basis of Coulomb's law that the equations of Bohr were derived.

In spite of this and other similar serious objections to Bohr's atomic model, I should not wish to minimize the importance of his work. He has been the first to present any sort of acceptable picture of the mechanism by which spectral series are produced, and especially he has traced a relation between two important constants of nature, Rydberg's fundamental frequency, and the Planck constant *h* which plays so important a part in modern physical theory. I should therefore be loath to suggest an abandonment of the extremely interesting leads which Bohr's theory has suggested, nor do I think this necessary, for I believe that relationships similar to those obtained in Bohr's theory may be obtained, even if we substitute for the orbital atom of Bohr a static atom, and, moreover, I believe that by making this substitution we may not only obtain a model of the atom which is consistent with known chemical facts, but also one which does not require the abandonment of the principal laws of mechanics and electromagnetics. I should state at once, however, that I do not claim for the atomic model, which I am about to sketch in rough outline, the same finality that I would claim, for example, for the molecular model of methane which I have previously offered.[3] It is rather a suggestion of the direction in which we may work towards the solution of a problem of extraordinary difficulty with the most hope of ultimate success. It is evident to any one familiar with the extreme complexity of the spectra of some substances that many years must elapse before anything approaching to a final explanation of such baffling phenomena can be expected. All we can do at present is to suggest certain directions of investigation which may lead ultimately towards the desired end. With this understanding, you will not consider it too presumptuous if I start by discussing not the structure of the complicated system that we call the atom, but rather the structure of the electron itself, or, if you prefer, the structure of the field of force about the electron.

If we postulate, at small distances, the nonvalidity of Coulomb's law of force between the centers of two charged particles, we are doing nothing that is really new. In the older conception of the electron as a charged sphere of definite radius, the sphere being itself held together

[2] It will be noted that this objection applies with equal force to the Planck oscillator which maintains energy even at the absolute zero.

[3] I refer here and elsewhere to my paper "The Atom and the Molecule," *J. Am. Chem. Soc.*, 38: 762, 1916. See also *Proc. Nat. Acad.*, 2: 586, 1916.

by forces of an admittedly mysterious character, Coulomb's law, in the ordinary sense, would fail when two electron centers approach within one electron diameter of each other. If, on the other hand, we abandon the rather artificial spherical model of the electron, and if we assume that the electron has all its charge concentrated at its center, then also it has been well recognized that Coulomb's law must fail, for otherwise we could not account for the finite mass of the electron. In this case also we might, if we chose, speak of the size of the electron, meaning thereby the distance from the center at which the electric force differs by a certain amount from that calculated by Coulomb's law. Now in either sense of the word we must agree with Rutherford that the positive nucleus of an atom is far smaller than the electron. In other words, two such positive nuclei will repel each other according to Coulomb's law even at distances so small that the law would have quite lost its validity for two electrons or for a positive particle and an electron. In other words, an atom composed of a single positive particle and an electron is to be regarded as though the positive particle were imbedded in the electron and not the electron in the positive nucleus, as in the older theory of J. J. Thomson.

Some years ago I was led, through consideration of electron theory alone, and by the aid of plausible assumptions, to an equation for the field of force about an electron, which, at that time, seemed to me a reasonable first approximation to the equation which we must substitute for Coulomb's law. If f is the force acting on an equal positive charge at the distance r from the point charge electron, if ϵ is the charge of the electron, e the base of natural logarithms, and r_0 a characteristic distance which does not differ much numerically from the radius which is ascribed to the spherical electron, the equation reads

$$f = \frac{\epsilon^2}{r^2} e^{r/r_0}.$$

At large values of r this obviously reduces to Coulomb's law; at small values it would correspond to a curve such as that given in Fig. 2, where f is the ordinate and r the abcissa.

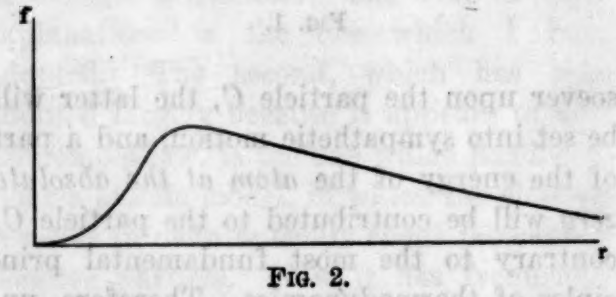

Fig. 2.

If now we assume that this is only a suggestion of the true equation and that the exponential term should be replaced by a similar function of periodic character, say a trigonometrical function of $1/r$, we might obtain an equation roughly represented by the curve given in Fig. 3. Any ordinary

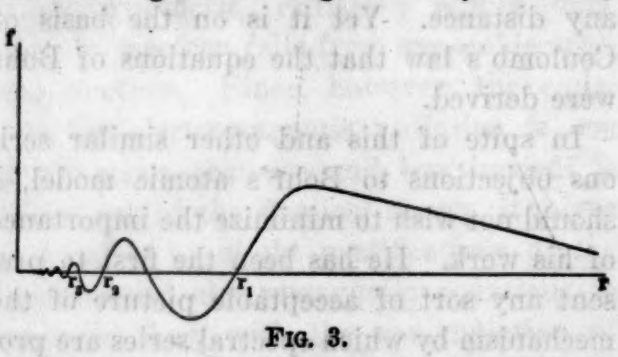

Fig. 3.

periodicity with respect to $1/r$ will make the curve which is plotted with respect to r intersect the axis of abscissæ an infinite number of times as r approaches zero. A positive particle (which we may regard as negligible in size but greatly preponderating in mass) situated at any of the intersections r_1, r_2, etc., where with diminishing r the force of attraction goes over into one of repulsion, is in a state of equilibrium with respect to the electron. Let us assume that

the slope of the curve at each intersection increases towards a finite limit as r approaches zero. This slope df/dr is the restoring force per unit displacement, and its square root determines the natural frequency of oscillation of the electron.[3] We thus have a picture of a system which, consistently with recognized principles of mechanics and electromagnetics, would give a series of spectral lines analogous to the series which are known for various elements. The limiting value of df/dr as r approaches zero determines the limiting frequency of the series. In the case of Balmer's hydrogen series this limiting frequency is equal to one fourth of the fundamental frequency which Rydberg has found associated with the series of a large number of elements. It has been argued that the existence of this fundamental frequency speaks for similarity of constitution of different atoms. Is it not simpler to assume that it is characteristic of the one thing which is common to all atoms emitting light, namely, the electron?

The condition which we have imposed regarding the slope of our curve at its intersections does not determine the area which will lie under any section of it. As the curve is drawn, the area under the r axis between r_1 and r_2, r_2 and r_3, etc., is greater than the area above the axis. In other words, the potential energy of the system increases as the positive particle is brought from r_1 to r_2, from r_2 to r_3, and so on. If now we fix the form of the curve so that $\int_{r_m}^{r_n} f dr$ is proportional to the difference between the values for r_n and r_m of $(df/dr)^{1/2}$, the potential energy of our system at any point of equilibrium is a linear function of the frequency which is characteristic of that position of equilibrium. We then have what is, to my mind, a very suggestive explanation of the Einstein photo-electric equation. If an electron moving with a given velocity meet a positive particle, the latter would penetrate the electron field to one of the positions of equilibrium, and the electron would oscillate with a frequency depending solely upon the equilibrium position it reaches and therefore upon its original kinetic energy. The higher the original velocity, the higher the frequency it is capable of exciting. On the other hand, if we assume the presence of atoms in which the electrons are in various positions of equilibrium with respect to the positive particle, and these atoms are subjected to light of a given frequency, the electron which possesses this as its natural frequency will oscillate with greater and greater amplitude until it is able to leave its position of unstable equilibrium and will then be ejected from the atom, acquiring a kinetic energy equal to the potential energy of its original position. On our assumptions the relation between frequency and velocity will be quantitatively that given by the Einstein equation.

In the time which has been allotted to me I can not further elaborate these points, but I hope that I have succeeded in making it seem plausible that some model of a static atom, perhaps only roughly resembling the one that I have outlined to you, may be expected to give at least as satisfactory an explanation of the phenomena of spectroscopy, and of the rela-

[3] It will of course be understood that, owing to its much smaller mass, it is the electron that oscillates and not the positive particle. I am referring above to oscillations in the line of centers. In general the oscillations of an object which is held in space in a fixed position by constraints which differ in different directions will be resolved by either mathematical or physical analysis to give three frequencies corresponding to the three axes of constraint. If the constraint along two of these axes is the same the corresponding two frequencies will be identical. I venture to offer this as an explanation of the well-known fact that the lines of a series spectrum occur often as pairs or triplets.

tionships between the natural constants which have been found in the study of radiation, as can be afforded by the orbital atom. If this is granted we may proceed with greater confidence to the further study of the group of atoms which we call the molecule, and to the nature of valence. I can not repeat here the reasons which I have given in another place for believing that it is these very electrons held in rigid positions in the outer shell of the atom which may, in case of chemical combination, become the joint property of two atoms, thus linking together the mutually repellant positive atomic kernels and themselves constituting the *bond* which has proved so serviceable in the interpretation of chemical phenomena. In some molecules, such as those of nitrogen, the linking electrons are held by powerful constraints. The molecule is inert and incapable of taking part readily in chemical reaction. In others, like those of iodine, in which the bond is said to be weak, the connecting electrons are held by loose constraints and the molecules are extremely reactive. But whether the bond be weak or strong, we may feel pretty sure that it solely consists of those electrons which are held as the joint property of two atomic shells and constrained to definite positions by forces which we do not at present understand, but which do not obey the simple law of inverse squares which characterizes the attraction or repulsion of charged bodies at relatively large distances from one another.

Gilbert N. Lewis
University of California

ZOOLOGICAL RESEARCH[1]

I speak with mixed emotions. I long ago planned to attend this spring meeting of the Indiana Academy of Science, the first I have been able to attend in several years. I was asked to assist at the dedication of a new biological building, and find I am one of the orators on the rare occasion of the unveiling of a monument to a man still alive and present. It is not possible to speak in the presence of so lively a corpse of the appropriateness of having your newest and best building named in honor of Stanley Coulter. If he were not present and listening with such apparent anxiety, I should like to recall his many good qualities and my good fortune in being associated with him for a third of a century. In these years we have traveled together, played together, worked together, fought together and against each other, and I think I am beginning to know him in part. It would make him too vain were I to say all of the nice things I should feel more than justified in saying, if his family were in mourning. As it is, I can only commend the authorities in honoring the teacher, the director of the Indiana Biological Survey, the charter member of the Indiana Academy of Science, the leader in nature study, the investigator, the dean of the school of science of Purdue University, and over and above all, the real human being.

It will not detract from his merits if I tell you in confidence that he deserves but part of the credit for what he has done. The poet truly said: "There is a Divinity that shapes our ends." At least half the credit should go to his wife, who has made him possible, and whom those of us who know her love even more than we do Stanley. I hope, I am sure the Academy as well as Purdue University hope, that they will long be able to work in the building so well named. The best of it is that the building was not needed to perpetuate the memory and influence of our friends.

The dedication of this, your best building, in part to zoology is a just recognition of the importance of the subject. It is quite proper, therefore, that we should consider what we mean by zoology, for our interpretation determines the nature of the work to be done within the walls of Stanley Coulter Hall.

Zoology is a study of animals. The study of

[1] Remarks at the dedication of Stanley Coulter Hall, the new biological building at Purdue University, during a meeting of the Indiana Academy of Science.

zoology as an intellectual pursuit gives liberal cultural training as well as a fuller appreciation of our fellow mortals. This fact in itself is a full justification of its study. But, in addition, zoology may be and is studied for the grounding preliminary training of certain of the professions, notably medicine and agriculture. The premedical man finds in zoology the basis for his future appreciation of the anatomy of man. Man carries many reminiscences of his lowlier ancestors. Even the over-devout believers of special creation seem to have had an inkling of this fact. On the walls of the sacred cemetery in Pisa a painter has represented the creation of man. On the left is the Lord, in the center is the man partly formed. To fill a gap in his canvas the painter placed a palm tree on the extreme right of the picture. A monkey is climbing the palm. Thus while the Lord is creating man "in His own image" a monkey is gamboling before his eyes—the result is only what might have been expected.

Zoology has an additional importance to the doctor of medicine. Man, himself a zoological garden, is involuntarily harboring within, and frequently without, many of his zoologically more humble contemporaries. It must frequently be a question whether the malady is due to the anatomy and physiology of the patient himself, or to the depredation of the invaders.

Here at Purdue University it is quite proper that another phase of zoology should receive full recognition. The firing line in the most important struggle for existence on the globe is not along the Marne, but in man, in his flocks, his cultivated fields and forests. The supreme struggle is not between autocracy and democracy, but between man and insects and still lower creatures. Insects keep many large parts of the globe as free from man as No Man's Land, much freer than the submarine zone. Insects and still lower animals levy their enormous tribute at the source. Some day we may issue liberty bonds to open the lanes of travel in other parts of South America as we have opened those of Panama, and to free us from the tribute we are compelled to pay to the Hessian fly, the gypsy moth, the San José scale, the Mexican cotton-boll weevil, the English sparrow, the Colorado beetle, the German carp, and a host of other invading and native marauders.

A few years ago I had the pleasure of sailing to St. Thomas, St. Croix, St. Kitts, Santa Lucia and other West India Islands as holy as these, though not yet sainted. Some had elaborate barracks, but fortifications were being abandoned and attention lavished on botanic gardens and experiment stations. The change was a recognition of this ancient, but only recently fully recognized, firing line. We certainly have abundant excuse, if excuse is needed for this new biological building.

But there is another use for this building. It is no merit to call the doctor when the stomach aches. It *is* a supreme merit to investigate causes and prevent future stomach aches while we are enjoying our daily overabundant meals.

We must investigate zoology from its pure and abstract side, developing as a by-product of our investigations the future Pasteurs, Kochs and Darwins; we must extend human knowledge. All institutions must cooperate in this, must grow at the tip. Investigation is the truest preparedness, and the democracies ought at least to encourage research as much as the autocracies, known for their noble contributions in this direction.

In this connection I would like to quote (with slight modifications) from a letter to President Stanley Hall, of Clark University, written in answer to a questionnaire on the general subject of what can be done to increase research in American universities.

BLOOMINGTON, IND., Oct. 25, 1916

My dear Dr. Hall: It would be very easy to point out why the American universities do not do more for research, why you must ask the first of your questions. But, my dear President Hall, a candid statement would be sure to be resented by one or another university active in the councils of the Association of American Universities. To call attention to self-evident facts would seem like interference on the part of one institution with the internal policy of another. In criticism of the policy of American universities in regard to research, the head of one of the great research en-

dowments remarked that his institution was appropriating more money to carry on research in one of the great universities than the university itself is devoting to this purpose. In visiting alumni associations the ambassador of another great institution bragged about the millions that were going into new buildings. At the same time there was internal complaint that research was being hampered by the lack of funds! Instances where research is eking out its hampered existence by the side of a great athletic plant or by the side of splendid costly halls, if not between the two, are not unique. As I am not permitted to stir up the animals—the very expression so unacademic—I will, in as academic and wooden a way as possible, discuss some of your questions, and point out in a mild way how the Nirvana of the research man may be approached, if not attained.

The first point in your circular letter raises the question of the function of the university, and of the university professor. Minot said that the function of the professor is "to carry on research and to teach others to do the same." If research is the function of the professor, *ipso facto*, it must be the function of the university. I think Minot's definition should include the central idea on which a prominent research institution was founded, if not conducted; to find the exceptional man and enable him to do the work for which he is best fitted. We will grant for the time, then, that it is the function of the university to find the exceptional man to carry on research, to enable him to make the most of his ability, and in his turn, to find exceptional men and enable them to do their utmost.

To this, the primary function of the university, as a close second comes the function of finding the other exceptional man, who can appreciate pure research and who is willing to let the university be the mediary between his own dollars and the university's research man.

If we grant all of the above, the answer to your first question becomes easy. If it is the function of the university to carry on research, there is evidently no reason why it should not engage men to carry on this function. Whether such men, or such a man, should devote part of his time, all of his time, or sporadically all of his time during leave of absence, are subsidiary questions, once it is granted that it is the function of the university to carry on research. University presidents, I fear, are usually too prone to believe in the efficacy of devotion, only so long as it is offered within hearing of the college bells. . . . The Carnegie Foundation has been criticized because it no longer pensions university professors with research proclivities at the end of twenty-five years of teaching. But, if it is the function of the university to carry on research, why should such men be pensioned? If the man is so wrapped up in research that he is willing to retire on decreased pay, that he may be able to devote himself exclusively to research, why not let him continue in one of the chief functions of the university on full, if not increased pay? The universities are trying to shirk when they criticize the Carnegie Foundation, because it refuses to help them carry on one branch of their work.

It goes without saying that the research man needs appropriations for apparatus or collections, or assistants or traveling expenses, and for publication. He can get some, if not all of these things, by cooperation with other institutions, the Carnegie Institution, the Elizabeth Thompson Science Fund, the Bache Fund, the American Association for the Advancement of Science, not to mention some others which help with money, or which cooperate in the matter of publication. The necessity for and existence of these research funds and institutions lies in the fact that the universities themselves failed to appreciate the necessity for research, failed to make adequate provision for it. The research funds stand in the same relation to the universities and to the public, that the interurban railways stand to the steam railways and the public. Frequently the time of the research man consumed in diplomacy, in getting the cooperation of people and institutions inclined for the most part to pull in different directions, could have been spent to better advantage in other ways. Digging the bait is more laborious, and always more tiresome, than fishing.

If it is the function of the university to carry on research and to teach others to do so, then of course, the university should discriminate between those gifted in teaching and those gifted in investigation. Your very question, "Must the many other research institutions outside the universities be mainly relied upon for this work?" is sin against the Holy Ghost.

The centers of some lines of pure research, cytology and genetics for example, had shifted to America before the great war. With the untempered democracy of high explosive shells of both contestants, which kill the most highly trained specialist by the side of the day laborer, it will naturally become the duty as well as the privilege of America, to still further enter into

friendly rivalry with Europe—for it is to be hoped that in the field of scientific research, there will be no trace of any but friendly attitude toward any of the European countries.[2] America will ultimately lead in idealistic endeavors. It would have done so, war or no war. The thing that will help more than any other to give leadership, is to have the universities make a special effort to gather the funds needed, to enable the men specially gifted in research to do their utmost.

Having secured the building, Mr. President, I hope you will provide the money to enable the men who are to be housed in it to do their best.

C. H. EIGENMANN

SCIENTIFIC EVENTS

RECONSTRUCTION HOSPITALS AND ORTHOPEDIC SURGERY

THE Surgeon General of the Army, Major General William C. Gorgas, authorizes the publication of the statement that the whole conception of governmental and national responsibility for caring for the wounded has undergone radical change during the months of study given the subject by experts serving with the Medical Officers' Reserve Corps and others consulting with them. Instead of the old idea that responsibility ended with the return of the soldier to private life with his wounds healed and such pension as he might be given, it is now considered that it is the duty of the government to equip and reeducate the wounded man, after healing his wounds, and to return him to civil life ready to be as useful to himself and his country as possible.

To carry out this idea plans are well under way for building "reconstruction hospitals" in large centers of population. Sites have been chosen, though not all finally approved, in the following cities: Boston, New York, Philadelphia, Baltimore, Washington, Buffalo, Cincinnati, Chicago, St. Paul, Seattle, San Francisco, Los Angeles, Denver, Kansas City, St. Louis, Memphis, Richmond, Atlanta, and New Orleans. Those in Boston, New York, Washington, and Chicago will probably be constructed first. Each will be built as a 500-bed hospital, but with provision for enlargement to 1,000 beds if needed.

These hospitals will not be the last step in the return of the wounded soldiers to civil life. When the soldiers are able to take up industrial training, further provision will be ready. The injured man may be retrained to his previous occupation to conform with his handicapped condition or retrained for a new industry compatible with that condition. Additional education will be given to those fitted for it, and men may in some cases be returned to more valuable work than that from which they were called to war. Workshops will be provided at the hospitals, but arrangements will also be made with outside industries whereby more elaborate methods of training may be carried on. An employment bureau will be established to place men so trained in different parts of the United States.

This whole matter comes under the department of military orthopedic surgery recently organized in the Medical Department of the Army. The following officers of the Medical Reserve Corps are in charge of the work: Major Elliott G. Brackett, of Boston, director of the department of military orthopedics to the Surgeon General; Major Joel E. Goldthwait, of Boston, director of military orthopedics for the expeditionary forces; Major David Silver, of Pittsburgh, assistant director of military orthopedics to the Surgeon General. The following, in conjunction with the above staff, compose the orthopedic council; Dr. Fred H. Albee, of New York; Dr. G. Gwilym Davis, of Philadelphia; Dr. Albert H. Freiberg, of Cincinnati; Dr. Robert W. Lovett, of Boston; and Dr. John L. Porter, of Chicago.

Arrangements have been made by the department of military orthopedics to care for soldiers, so far as orthopedics (the prevention of deformity) is concerned, continuously until they are returned either to active service or civil life. Orthopedic surgeons will be attached to the medical force near the firing line and to the different hospitals back to the base orthopedic hospital, which will be established within 100 miles of the firing line. In this hospital, in addition to orthopedic surgical

[2] This letter was written before the United States entered the war.

care, there will be equipment for surgical reconstruction work and "curative workshops" in which men will acquire ability to use injured members while doing work interesting and useful in itself. This method has supplanted the old and tiresome one of prescribing a set of motions for a man to go through with no other purpose than to reacquire use of his injured part.

In addition to the American orthopedic surgeons now working abroad under Col. Jones, of England, others will soon go overseas. Experienced surgeons, and a large number of younger surgeons who will work under competent directors, will go abroad for this work, all to be under the direction of Major Goldthwait. These orthopedic surgeons will work in England among the British force and when needed will be transferred to France to work among American soldiers.

It is not the intention that men able to go back to the firing line shall be returned to this country unless their convalescence will extend over a period of a considerable number of months. Soldiers unable to return to duty will be sent to the reconstruction hospitals in the United States.

Instructors and examiners for all the camps are also being furnished by the department of military orthopedic surgery. A number of older and more experienced surgeons will act as instructors and supervisors for each of the groups into which the camps will be divided; a number of orthopedic surgeons will be detailed as attending surgeons at each camp to act as examiners and as consultants to the camp's other surgeons.

FOREST BATTALIONS FOR SERVICE IN FRANCE

THE formation of a second "Forest" regiment comprising ten battalions and composed of lumbermen and woodworkers, who will go to France and get out of the forests materials for the use of the American, French and British armies, has been authorized by the War Department.

Two battalions are to be raised at once with the active aid of the Forest Service of the Department of Agriculture. It is expected that the remaining eight battalions will be called for in a short time. Nine "service" battalions, made up of laborers who will be used in connection with the Forest regiment, have also been authorized and two battalions have been ordered raised at once.

In order to provide for future contingencies it has been decided to commission at the present time enough officers for other battalions yet to be raised. Those men not needed now will be placed on the reserve, and will be called as the other units are formed. According to the present plan, fifty per cent. of the officers will be sawmill and logging operators, twenty-five per cent. will be technical foresters, and twenty-five per cent. will be men with military tenants will be selected in the immediate future. The minimum age limit for commissioned officers has been set at thirty-one.

A considerable number of captains and lieutenants to be selected in the immediate future. The minimum age limit for commissioned officers has been set at thirty-one.

A first regiment of woodsmen numbering about 1,200 men and designated as the Tenth Engineers (Forest) has already been recruited and assembled and is now being trained at American University, D. C. This regiment was raised at the request of the British government to undertake the production in France of crossties, bridge, trench and construction timbers, mine props, lumber, and other forms of wood required in connection with its military operations. The landing of the American expeditionary forces has made necessary similar provision for their needs, while the French military authorities have indicated that some of the work incidental to their operations might be taken over by woodsmen from this country. Decision to raise the new and much larger force has followed a study of the field of possible usefulness to the Allied cause, made by American foresters attached to General Pershing's staff.

Each of the ten battalions of the second regiment will comprise three companies of 250 men each, and will be under the command of its own major. The regiment will be made up of volunteers. Applicants must be white and between the ages of eighteen and forty.

Skilled lumberjacks, portable mill operators, tie cutters, logging teamsters, camp cooks, millwrights and charcoal burners are among the classes of men desired. For the "service" battalions both negro and white laborers will be enlisted.

OCCUPATIONAL CENSUS OF THE ARMY

THE War Department has authorized the following statement:

There is now being made under the direction of the Adjutant General a comprehensive occupational and educational census of the men of the National Army.

The object is to carry the selective service law to its logical conclusion and to increase the efficiency of the army by putting the right man in the right place.

With this in view, a personnel organization has been established in each of the 16 cantonments. The previous occupation, education and preference for service of every man are recorded on individual cards, which are then filed and analyzed at the divisional personnel office in each cantonment. An analysis as to the entire 687,000 men of the first increment can readily be made from these records.

In this work the War Department is having the assistance of a body of civilian experts organized under the name "Committee on classification of personnel in the Army" and including a number of professional employment managers loaned to the government by large industrial and business concerns. The data collected will be used within the divisional organizations to assist division commanders in making the best possible assignment of their men. It will also be of importance in locating men fitted for special branches of the service, such as Aviation, the Ordnance Corps, etc., for which it may be necessary to assign men from the cantonments.

It must not be assumed that men can continue their old occupations in the army. The function of an army is to fight and most of the men irrespective of previous occupations, will be in the infantry and artillery. Nevertheless, the specialization of modern war requires large numbers of skilled men adapted for technical units and special branches of the service. The locating and placing of such men to the best advantage is of vital importance.

OPPORTUNITY FOR PHYSIOLOGISTS AND BIOCHEMISTS

THE Surgeon General of the army is organizing a Food Division of his office, the object of which is to safeguard the nutritional interests of the army by means of competent inspection of food from the standpoint of nutritive value, the supervision of mess conditions, including the economical utilization of food, and a study of the suitability of the army ration for troops in the camp and in the field. Well-trained physiologists and biochemists are needed to direct this work. These men are being commissioned, according to age and experience, as first lieutenants and captains in the Sanitary Corps, Medical Department; or, if they have medical degrees, in the Medical Reserve Corps.

It is probable there will be as many commissioned officers as there are camps and cantonments. Nutritional surveys will be conducted at the camps by surveying parties composed of these commissioned officers, and of drafted men, who have had scientific training, acting as assistants and clerks. It is estimated that such a survey can be completed in from ten days to two weeks for each camp.

It is hoped by means of these surveying parties also to instruct the company mess sergeants and company cooks in improved methods of selecting and preparing the foods. A school for the finished training of the scientists employed in this work is now being organized. The organization of the army, the army methods of handling and cooking foods, the latest methods of food examination and analysis, the conduct of the food survey and kindred topics will be covered by competent instructors from various departments of the army and other departments of the national government.

The facilities of the Bureau of Chemistry, including its analytical laboratories scattered over the country, have been placed at the disposal of the Food Division for this work. Analyses of the garbage will be made and of all foods whose composition is not already known, and the actual distribution of nutrients and of total calories consumed by the men will be com-

puted. Any alteration of the army ration in the future will be based only upon the facts as thus gathered. There is every promise that this service will prove to be of strategic importance in the control of the health and welfare of the troops from the place of their mobilization to the battle front.

PSYCHOLOGICAL EXAMINATION OF RECRUITS

Appointments for psychological examiners in the National Army Cantonments, Camp Lee, Petersburg, Va.; Camp Dix, Wrightstown, N. J.; Camp Devens, Ayer, Mass.; Camp Taylor, Louisville, Ky., have been made as follows:

Major, Robert M. Yerkes, Surgeon General's Office, in charge of psychological work. Lieutenant Arthur S. Otis in charge of statistical work in the Surgeon General's Office, Section of Psychology.

Lieutenants Clarence S. Yoakum, Marion R. Trabue, Jos. W. Hayes, and Wm. S. Foster to serve as chief psychological examiners.

Lieutenants Geo. O. Ferguson, Jr., Walter S. Hunter, Edw. S. Jones, Karl T. Waugh, Heber B. Cummings, Edgar A. Doll, John T. Metcalf, Herschel T. Manuel, Carl C. Brigham, John E. Anderson, Horace B. English and Harold A. Richmond to serve as psychological examiners.

In addition to the above commissioned examiners, the following have been given civil appointment for psychological examining: Doctors Leo J. Brueckner, Donald G. Paterson, A. S. Edwards, Rudolph Pintner, Benj. F. Pittenger, Ben. D. Wood, John W. Bridges, J. Crosby Chapman, John K. Norton, Edward C. Rowe, J. David Houser, C. P. Stone, Thos. H. Haines, Norbert J. Melville, H. P. Shumway, Chas. H. Toll, Thos. M. Stokes, C. C. Stech, John J. B. Morgan, Raymond H. Wheeler, Harold C. Bingham, Carl R. Brown, Chester E. Kellogg, Ralph S. Roberts, and D. L. Hoppinginer.

SECTION OF ZOOLOGY OF THE AMERICAN ASSOCIATION

The annual meeting of Section F (Zoology) of the American Association for the Advancement of Science will be held at Pittsburgh, Pa., during Convocation Week on Saturday, Monday and Tuesday, December 29, 31 and January 1, under the presidency of Professor Herbert Osborn, of the Ohio State University. The opening sessions on Saturday will be devoted to the reading of technical papers, the titles of which together with brief abstracts of not over three hundred words must be in the hands of the secretary not later than December 10 in order to appear on the printed program. A joint smoker with the American Society of Naturalists is planned for Saturday evening.

The address of the retiring vice-president will be read by Professor George Howard Parker, of Harvard University, at the morning session on Monday, December 31. The "General Interest Session" will be held on Monday afternoon and will consist of a symposium on "The Contribution of Zoology to Human Welfare." Papers on this important subject will be read by Doctor Hugh M. Smith, U. S. Commissioner of Fisheries; Dr. L. O. Howard, chief entomologist of the U. S. Department of Agriculture; Dr. Charles Wardell Stiles, U. S. Public Health Service; and Professor Maurice A. Bigelow, director of the School of Practical Arts of Columbia University. The sessions of Tuesday, January 1, will be held in conjunction with the American Society of Naturalists and will close with the Naturalists' dinner on Tuesday evening.

SCIENTIFIC NOTES AND NEWS

The Surgeon General of the army, Major General William C. Gorgas, has established a board to collect material for the medical and surgical history of American participation in the European War. This board is composed of Colonel C. C. McCulloch, librarian of the Army Medical Library; Major F. H. Garrison, assistant librarian in direct charge of work on the history, and Captain John S. Fulton, secretary of the Maryland State Board of Health, who will have charge of the statistical work.

Dr. Veranus A. Moore, dean of the veterinary college of Cornell University, has been in Washington, serving as an adviser of Surgeon General Gorgas in the organization of the

Veterinary Officers' Reserve Corps. Dr. Moore is a member of the committee on military service of the American Veterinary Medical Association. That committee had been serving as a board advisory to the Surgeon General and Dr. Moore was elected to represent it in the Surgeon General's office.

DR. A. R. DAVIS, assistant professor of agricultural botany, the University of Nebraska, has been commissioned captain in the Coast Artillery, U. S. R. He is at present assistant ordnance officer, Fort Howard, Maryland.

CARL H. BUTMAN, who has been editorial assistant at the Smithsonian Institution for the last seven years, has resigned to become Washington editor of a new aviation magazine, *Air Service Journal.*

PROFESSOR ARTHUR D. BUTTERFIELD, head of the department of mathematics of the Worcester Polytechnic Institute, has resigned, as he expects to be called for service as captain in the aviation branch of the signal corps. Professor David L. Gallup, head of the gas engineering department, will also resign on October 1, having accepted a position as head of the research laboratories of the Nordyke & Marmon Company.

PROFESSOR A. M. BUCK, who for the last six years has been in charge of electric railway courses at the University of Illinois, has resigned to join Mr. John A. Beeler, of New York, in the consulting field. His new work will consist largely of investigations dealing with the construction, operation and management of electric railway properties.

DR. MAX KAHN has resigned his position as biochemist to the Western Pennsylvania Hospital, Pittsburgh, Pa., to accept the appointment of director of the laboratories, Beth Israel Hospital, New York City.

GEORGE H. STICKNEY, of Montclair, N. J., has been elected president of the Illuminating Engineering Society.

THE recently established Engineering Council has appointed the following standing committees: On Public Affairs—C. W. Baker, G. F. Swain, S. J. Jennings and E. W. Rice, Jr. On Rules—J. P. Channing, Clemens Herschel, N. A. Carle and D. S. Jacobus. On Finance—B. B. Thayer, I. E. Moultrop, Calvert Townley and Alexander C. Humphreys. The council has also created a war inventions committee, comprising H. W. Buck, A. M. Greene, Jr. and E. B. Kirkby, to cooperate with the Naval Advisory Board and other departments at Washington. It also created a committee, comprising George J. Foran, E. B. Sturgis, A. S. McAllister and A. D. Flinn, which is to collect and compile such information regarding engineers of the country as will enable it to cooperate with the different departments of the federal government.

IT is stated in *Nature* that a committee to inquire into various matters connected with the *personnel* and administration of the army medical services has been appointed by the British Secretary of State for War. The committee is composed of Major-General Sir F. Howard (chairman), Sir Rickman J. Godlee, Bart., Sir Frederick Taylor, Bart., Sir W. Watson-Cheyne, Bart., Dr. Norman Walker, Lieutenant-Colonel A. J. Stiles, Dr. Buttar and Dr. J. B. Christopherson (secretary). It will begin its work in France, and afterwards carry out similar investigations in England.

Two new orders have been instituted by the British king in recognition of services rendered by British subjects and their Allies in connection with the war, viz., the Order of the British Empire and the Order of the Companions of Honor. The Order of the British Empire has five classes, viz.: *Men:* (1) Knights Grand Cross (G.B.E.); (2) Knights Commanders (K.B.E.); (3) Commanders (C.B.E.); (4) Officers (O.B.E.); (5) Members (M.B.E.). *Women:* (1) Dames Grand Cross (G.B.E.); (2) Dames Commanders (D.B.E.); (3) Commanders (C.B.E.); (4) Officers (O.B.E.); (5) Members (M.B.E.). The first two classes, in the case of men, carry the honor of knighthood, and in the case of women the privilege of prefixing the title "Dame" to their names. The first lists of appointments to the orders have been issued. *Nature* selects the following as those known for contributions to science: To the Order of the British Empire: Lord Moulton and Lord Sydenham (G.B.E.); Mr. Dugald

Clerk, Professor H. S. Jackson and Mr. R. Threlfall (K.B.E.); Dr. Garrett Anderson, Professor H. B. Baker, Mr. L. Bairstow, Professor W. H. Bragg, Professor S. J. Chapman, Mr. W. Duddell, Mr. F. W. Harbord, Professor F. W. Keeble, Dr. Mary A. D. Scharlieb and Professor J. F. Thorpe (C.B.E.); Professor J. C. McLennan (O.B.E.). The following have, among others, been appointed Companions of Honor: The Hon. E. Strutt and Professor Ripper.

According to the London *Times* the program for the autumn meeting of the Iron and Steel Institute, held at the Institution of Civil Engineers on September 20 and 21, included the following papers: "Present practise in briquetting of iron ores," by G. Barrett and T. B. Rogerson; "Microstructure of commercially pure iron between Ar_3 and Ar_2," by W. J. Brooke and F. F. Hunting; "The influence of heat treatment on the electrical and thermal resistivity and thermo-electric potential of some steels," by E. D. Campbell and W. C. Dowd; "New impact testing experiments," by G. Charpy and A. Cornu-Thénard; "Heat treatment of gray cast iron," by J. E. Hurst; "Effect of mass on heat treatment," by E. F. Law; "Investigation upon a cast of acid open-hearth steel," by T. D. Morgans and F. Rogers; "The acid open-hearth process," by F. Rogers; "The Eggertz test for combined carbon in steel," by J. H. Whiteley, and "Failure of boiler plates in service, and investigation of stresses occurring in riveted joints," by E. B. Wolff.

The autumn meeting of the Institute of Metals was held in the rooms of the Chemical Society, London, in Burlington House, on September 19. The papers presented were: "Experiments on the fatigue of brasses," by Dr. B. Parker Haigh; "Hardness and hardening," by Professor T. Turner; "The effects of heat at various temperatures on the rate of softening of cold-rolled aluminium sheet," by Professor H. C. H. Carpenter and L. Taverner; "A comparison screen for brass," by O. W. Ellis; "Further notes on a high temperature thermostat," by J. L. Haughton and D. Hanson; "Principles and methods of a new system of gas-firing," by A. C. Ionides; "Fuel economy in brass-melting furnaces," by L. C. Harvey, with additional notes by H. J. Yates; "The effect of great hydrostatic pressure on the physical properties of metals," by Professor Zay Jeffries, and the "Use of chromic acid and hydrogen peroxide as an etching agent," by S. W. Miller.

We learn from *Nature* that donations and promises towards the Ramsay Memorial Fund received by the treasurers amount so far to £21,352, including £835 from members of the British Science Guild; £500 from Sir George Beilby, and £100 each from Lord Rosebery, the Company of Clothworkers, and the Salt Union, Ltd. Professor Orme Masson, of the University of Melbourne, has undertaken to act as the representative and corresponding member of the committee for Australia. As already announced, Professor C. Baskerville, of the College of the City of New York, is acting in a similar capacity for the United States.

Charles Lee Crandall, emeritus professor of railway engineering and geodesy in Cornell University, died at his home in Ithaca on August 25, aged sixty-seven years.

Dr. Lewis Atterbury Stimson, professor of surgery in Cornell Medical College, died on September 17, in his seventy-fifth year.

Mr. Walter E. Archer, known for his work on English sea fisheries, died on August 19 at Sand, Norway, at the age of sixty-two years.

Major A. N. Leeds, the English paleontologist, died on August 25 at the age of seventy years.

The first of the four volumes of the Decennial index to *Chemical Abstracts* was issued September 20. This first volume, which contains a little over 1,000 pages, is devoted to authors, A to K. The completed index will be virtually a complete record of the world's accomplishments in chemistry during the period 1907 to 1916.

The War Industries Board has requested the subcommittee on fertilizers to make an immediate survey of the nitrate of soda consumption and requirements in the fertilizer industry. Blanks are being mailed to the en-

tire fertilizer industry. It is requested that this information be placed in the hands of the War Industries Board at the earliest possible moment.

BY decree of September 12, the president of Cuba has modified the Commission of Plant Sanitation to an Office of Plant Sanitation with Mr. John R. Johnston, former president of the commission, remaining as chief of the office. The duties of this new office are the same as of the former commission, it being the sole office to issue certificates for the exportation of plants, in charge of all plant-quarantine problems, and entrusted with the eradication of the "black fly," *Aleurocanthus woglumi*, the control of the coconut budrot, the banana blight and other insect pests and plant diseases.

THE report of the Education Branch of the British Board of Agriculture and Fisheries for the year 1915–16 is summarized in *Nature*. The report is said to afford evidence that, despite the severe restrictions imposed by the war upon the development of agricultural education and research, much useful work was accomplished during the year under review. There was a great decrease in the numbers of students taking long courses of instruction, whereas the numbers taking short courses were more than maintained. The Royal Agricultural College, Cirencester, and the Agricultural College, Uckfield, Sussex, were closed and the grants were withdrawn from two other institutions as a measure of war economy. Research work suffered severely owing to the heavy drain upon the staffs for army or munition purposes, but much useful work on problems of immediate technical importance was accomplished, of which the investigations at Cambridge on wheat-breeding and at Rothamsted on soil and manurial problems may be singled out for special mention.

UNIVERSITY AND EDUCATIONAL NEWS

GOVERNOR JAMES E. FERGUSON, of Texas, has been impeached by the legislature. The charges against him were financial irregularities and improper interference with the board of regents of the state university. The bill providing for the financial support of the university for the next biennium, which was vetoed by Governor Ferguson, has been re-passed by the legislature and signed by the acting governor. The professors who were dismissed at the instigation of Governor Ferguson have been reinstated.

YALE UNIVERSITY has received since commencement gifts amounting to $362,393.05. The largest was $100,000 from Mrs. Edward H. Harriman for the Harriman Fund for Obstetrics in the Medical School. Another gift was that of $50,000 from Charles F. Brooker, of Ansonia, also for the Medical School.

IT is now announced that the offer of the opening of the Harvard Medical School will be withdrawn, only one woman having replied, who was regarded as a desirable student.

PROFESSOR WALTER E. CLARK, head of the department of political science in the New York City College, has been elected president of the University of Nevada.

GEORGE F. KAY, B.A., M.A. (Toronto), Ph.D. (Chicago), has been elected dean of the college of liberal arts of the University of Iowa. Dr. Kay will continue to be head of the department of geology in the university, and state geologist of Iowa.

MR. SIMON MARCOVITCH, assistant entomologist for the past three years at the University of Minnesota, has resigned his position to accept the position of head of the department of biology at the National Farm School, Bucks county, Pennsylvania.

EUGENE DEATRICK, Ph.D. (Cornell), has been appointed professor of soils at the Pennsylvania State School of Forestry, Mont Alto, Pa.

MR. HARRY B. YOCOM, who recently received his Ph.D. from the University of California, has been appointed to the professorship of zoology in Washburn College, Topeka, Kansas, to succeed the late Johnathan Risser.

DISCUSSION AND CORRESPONDENCE

THE COLORS OF LETTERS

SOME twenty-five years ago or more I published in *The Popular Science Monthly*, a little paper on "The Color of Letters." In it I referred to a curious form of association of

	Eric Jordan, 1912	Eric Jordan, 1917	David Starr Jordan	Majorie Edwards	Edith Snow
A	red	red bright	brown red	colorless	golden
B	bluish	gray	green	brown	dark blue
C	white	white	yellowish white	pink	pale yellow
D	bluish	gray	blue	purple	dark green
E	pale green	yellow	red	colorless	blue silver
F	red brown	brown	pale scarlet	scarlet	silver
G	pale brown	yellow	pale yellow	dark blue	pale brown
H	green	yellow	brown red	heliotrope	pale green
I	black	black	leaden black	red	silver
J	dark blue	greenish	leaden	dull green	red
K	brown	brown	lead violet	pink	plum color
L	pale green	green	green	yellow	dark green
M	red	brown	lead blue	dull rose	dark brown
N	pale greenish	light brown	brown red	pale green	brick red
O	light blue	black	white	orange	white
P	yellow	yellow	lead color	lavender	lemon yellow
Q	pale red	red brown	bluish white	yellow	drab
R	dark green	dark red	bright green	red	black
S	silvery gold	silver	bright yellow	green	pale red
T	white	silver	green	yellow	pale bluish green
U	yellow	yellow brown	yellowish	colorless	drab
V	silver	white	violet blue	black	blue green
W	red brown	brown	lead blue	white	blue black
X	silver	silver	scarlet	blue	red
Y	silver	white	blue	colorless	aark yellow
Z	reddish	dark brown	scarlet	green	dark red

color with the letters of the alphabet. This faculty has been called "Pseudo-chromæsthesia," which, I take it, means sensitiveness to false colors. It has been misunderstood by writers, who have imagined that the peculiar individuals having this trait actually see the color on the letter, which is not the fact. It is a mental association, not a false vision. Some have attributed it to a recollection of color blocks from which letters have been learned. To the "pseudochromæsthetic" this explanation is nonsense. It is, however, a fact that the tendency of this association of letters with colors is hereditary, and that it goes with a certain interest in word-using and in the use of color, features capable in each case of development.

When my son Eric was eight years old, no one ever having spoken of it to him before, I asked him what is the color of A? He responded at once that it is red. At that time, 1912, I made out a list of the alphabet with the colors assigned to each. Quite recently (1917) I repeated the question, never having mentioned the matter since. He said at once that A was red and seemed slightly surprised that any one should not see the difference in innate color between red A and yellow E.

A few changes appeared, however, in his chromatic scale. These seem, however, to indicate vagueness of color, as the same impression might be described as bluish in one case and greenish or gray in another. For the sake of those this note may interest, I append my own chromatic scale which has not changed appreciably since I first thought of it, with those of two former students, the one my own niece, Marjorie Edwards (now Mrs. Frank Blake), and Edith Snow, daughter of the late Dr. Frank Snow, former president of the University of Kansas.

David Starr Jordan

A SIMPLE DEMONSTRATION FOR EULER'S DYNAMICAL EQUATIONS

Teachers of analytic mechanics may perhaps be interested in a demonstration which I have used for the past two years and which seems to illuminate Euler's equations for the rotation of a rigid body. The experiment is so simple that it has doubtless been used before, but I do not recall ever seeing it described.

GH is an ordinary support rod some 70 cm. long. *IJ* is a suspending cord. The ring *I* is set at such a point that when the rod is at rest

the angle *GIJ* is somewhat less than 45°. The center of gravity of the system then lies vertically below the cord. Choose axes fixed in the body as follows: For the axis *1* take a horizontal line through the center of gravity and perpendicular to the plane *GIJ*, for axis *2* take the axis of the rod, and for axis *3* take a line

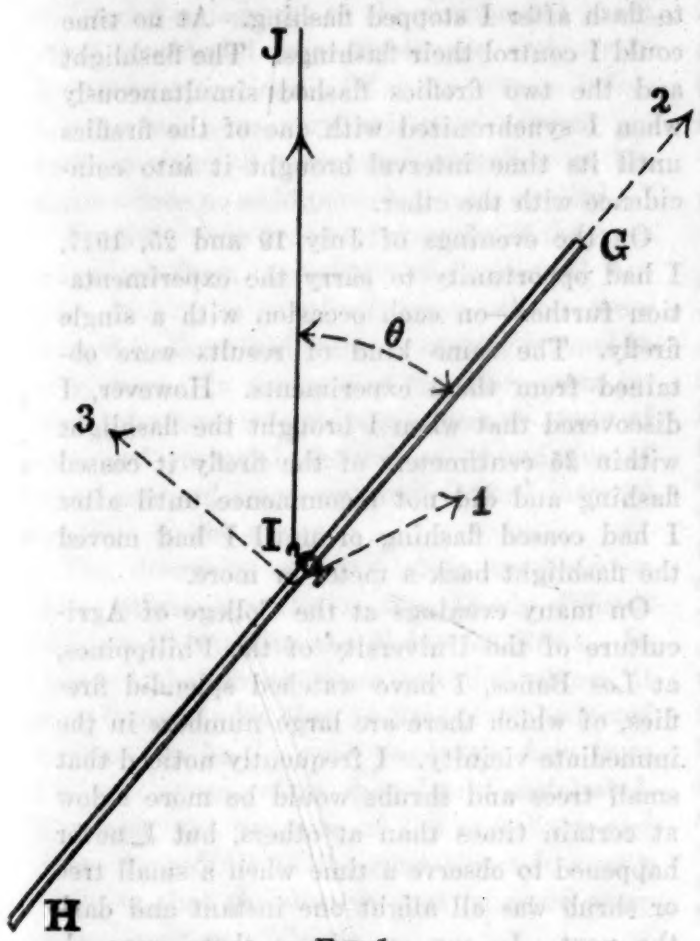

FIG. 1.

through the center of gravity and perpendicular to the plane of *1* and *2*. *3* will then lie in the plane *GIJ*. These axes are represented in the figure, where the axis *1* is supposed to project directly towards us, and the coordinate system is consequently right handed. Take right-handed rotation as positive. Then Euler's first equation may be written

$$A\frac{d\omega_1}{dt} - (B - C)\omega_2\omega_3 = L, \qquad (1)$$

where A, B, and C stand, respectively, for the moments of inertia about the axes *1*, *2*, *3*; ω_1, ω_2, ω_3 for the angular velocities about those same axes; and L for any external torque which may be acting about axis *1*. In the present case we have very nearly $B = 0$ and $C = A$, so that equation (1) becomes

$$\frac{d\omega_1}{dt} + \omega_2\omega_3 = \frac{L}{A}. \qquad (2)$$

Now give to the system a right-handed rotation about *IJ*. We then have $\omega_2 > 0$ and $\omega_3 > 0$. If the center of gravity were to stay immediately below the cord we should have $L = 0$ and therefore $d\omega_1/dt < 0$. But this would increase the angle θ and so throw the center of gravity out from underneath *IJ*. The weight of the system and the tension in *IJ* would then supply a positive torque L. It is possible to have this torque of such magnitude as to make $d\omega_1/dt = 0$, in which case the torque is entirely non-momental. The reason for the necessity of this non-momental torque is easily seen by considering an element of the rod near *G* or *H*. When the rod is rotating there must act upon this element a centripetal force directed toward the axis *IJ*. This force is supplied by means of the torque L.

A rotation of sufficient magnitude to make θ very evidently greater than it is when the system is at rest is easily imparted by hand.

ARTHUR TABER JONES
SMITH COLLEGE

A UNIQUE HORNET'S NEST

IN the magazine, *The Guide to Nature*, Vol. 10, No. 1, June, 1917, Earl A. Newhall, of Shelburne, Mass., under the title "The nest of an unknown hornet," mentions a hornet's nest of peculiar form which he found hanging under the eaves of an old shop. An excellent photograph of this strange nest accompanies the article. Newhall wrote to Dr. L. O. Howard, of the Bureau of Entomology, sending a photograph of the nest. Dr. Howard states:

I never saw a hornet's nest like the one in the photograph and I have referred your letter to Mr. S. A. Rohwer, of this bureau, who has studied these creatures for many years and he replies as follows: "I have never seen a nest like this before and do not know if it is an abnormal one or not. If possible, I should like to have some of the ma-

kers so that it would be possible to determine the species and thus know if it is abnormal habit.

The nest in question consisted of a globular portion which was abruptly contracted below into a long, slender, vertical neck of practically uniform diameter. This slender neck served as the only means of entrance into the structure.

The writer wishes to state that he once found one of these unique nests at Oxford, Mass., many years ago. This nest was kept as a curiosity in the writer's collections for many years and did not fail to excite the wonder and admiration of those who saw it. In size and shape this nest was similar to the one found by Newhall at Shelburne, Mass. Newhall states that he found his specimen under the eaves of a building. As well as the writer can remember, the nest which he found at Oxford, Mass., was suspended from a small branch of a tree not far from the ground. The maker of the nest was never seen. Although the writer has always kept a sharp eye open since for other specimens of this kind, none has ever been seen. It would be of considerable interest to know whether the two unique nests in question really represent abnormal deviations of habit for some well-known species, or the normal habit of nest-construction for a very rare and little known, or even unknown, species.

H. A. Allard
Washington, D. C.

SYNCHRONISM IN THE FLASHING OF FIREFLIES

The articles on the flashing of fireflies which have appeared from time to time in Science have aroused my desire to experiment upon the subject. The presence of two individuals of the firefly, *Photuris pennsylvanica* DeG., in my tent at the University of Michigan Biological Station at Douglas Lake, Mich., on the evening of July 17, 1917, gave me my first opportunity. With the tent dark, I watched the two fireflies for about ten minutes. For a while they flashed alternately, but it soon became apparent that one was flashing a trifle more frequently than the other. Consequently, once in every two and one half to three minutes flashing was simultaneous. Then for about twenty minutes I experimented with a three-celled vest pocket flashlight with the following results. I could easily get in rhythm with the firefly, but I could not make the firefly change its rhythm and keep with me. Sometimes the fireflies would stop while I was flashing the light and again they would continue to flash after I stopped flashing. At no time could I control their flashings. The flashlight and the two fireflies flashed simultaneously when I synchronized with one of the fireflies until its time interval brought it into coincidence with the other.

On the evenings of July 19 and 25, 1917, I had opportunity to carry the experimentation further—on each occasion with a single firefly. The same kind of results were obtained from these experiments. However, I discovered that when I brought the flashlight within 25 centimeters of the firefly it ceased flashing and did not recommence until after I had ceased flashing or until I had moved the flashlight back a meter or more.

On many evenings at the College of Agriculture of the University of the Philippines, at Los Baños, I have watched splendid fireflies, of which there are large numbers in the immediate vicinity. I frequently noticed that small trees and shrubs would be more aglow at certain times than at others, but I never happened to observe a time when a small tree or shrub was all alight one instant and dark the next. In my experience there were always some fireflies flashing in the *"dark"* periods. The times of greatest light occurred when the greatest number of varying flashes coincided.

From these observations and experiments it seems to me that complete synchronism in the flashing of a group of fireflies is simply a very rare accident, occurring when the flashes of the individuals chance to come at the same time.

Frank C. Gates
Carthage College,
Carthage, Ill.

UREDINIA OF CRONARTIUM RIBICOLA ON RIBES STEMS

During the past season uredinia of *Cronartium ribicola* Fischer have been discovered for

the first time on *Ribes* stems. Three natural stem infections were observed on a plant of *Ribes hirtellum* Michx. (*Grossularia hirtella* (Michx.) Spach) growing in a pine woodlot at Kittery Point, Maine. In this same woodlot two other isolated plants of the same species, inoculated with æciospores by applying the moistened æciospores to the unwounded green stems, developed respectively one and seventeen stem infections. Of the seventeen infections some were very evidently natural infections since they occurred at points on the stems where no æciospores had been applied.

Uredinia were produced on some of the stem infections from the middle of June until August 20. The urediniospores which were formed in these sori were apparently normal in every way. In the case of the other stem infections, where no uredinia appeared, study of sectioned material showed an abundance of mycelium and numerous well-formed internal uredinia in the cortex.

The discovery of sporulating uredinia on *Ribes* stems complicates the already difficult problem of detecting the disease on *Ribes*. In view of the observations recorded above, it must be concluded that no *Ribes* from infected regions can be declared absolutely free from the rust even when completely defoliated. Moreover, the presence of the mycelium and internal uredinia in the stem tissue is strong evidence that the disease does in some cases winter over on *Ribes*.

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SCIENTIFIC BOOKS

Dioptrographic Tracings in Three Normæ of Ninety Australian Aboriginal Crania. By DRS. RICHARD J. A. BERRY and A. W. D. ROBERTSON. Transactions of the Royal Society of Victoria, Vol. VI., 1914.

The volume at hand contains 270 "life-size" tracings of crania of Australian natives. The number of skulls dealt with is ninety, each one being represented uniformly from the front, side and top. The publication follows one of a similar nature in which tracings were given of 52 Tasmanian skulls, by the same authors, and reviewed by the writer in SCIENCE of December 16, 1910.

As to derivations, the skulls utilized with six exceptions are all from the southeast part of Australia, *i. e.*, from the region south of the Murray River; the six exceptions are from Queensland.

The authors accompany the publication with the statement:

> We are solely desirous of making available to our scientific colleagues elsewhere, material of a valuable character, and which is otherwise inaccessible, and which runs the further risk of being lost in the process of time unless so collected. We do not desire to impose our own deductions derived from a study of this material upon those who may hold different opinions from ourselves, and hence we do not incorporate here, nor did we do so with the Tasmanian tracings, the result of our own observations on highly debatable questions, with the material itself. The conclusions which we ourselves drew from the Tasmanian material have been published in the *Proceedings of the Royal Society of Edinburgh*, Volume 31, 1910, and similarly the conclusions which it is our intention to deduce from the present material will be made available elsewhere, and in due course. Thus those who desire to make use of the present material for other purposes will have a free hand both now and for the future.

As in the case of the tracings of the Tasmanian crania, anthropologists are thankful to Drs. Berry and Robertson for their painstaking work; but as the Tasmanian volume so the one at hand presents certain serious deficiencies which are badly felt and which can scarcely be compensated for by any subsequent publication on the series.

In the first place there is no identification and subdivision of the specimens according to sex. They are evidently all of adults, yet even this is not certain. But the most serious deficiency is the omission of all measurements. An illustration without at least two or three of the principal measurements does not convey, a full measure of confidence. It is probable

that the dimensions of the illustrations are perfectly true, but had a few measurements been given with each illustration this probability might have become a certainty.

The work incites, but does not satisfy; which should not be taken as criticism, but rather as a stimulus for the future. We need more than tracings. We need, in a most precise form, every possible detail concerning the cranium as well as the rest of the skeletal and physical make-up of the Australian; and may Drs. Berry and Robertson be soon in a position to give us this information.

Aleš Hrdlička

The Culture and Diseases of the Sweet Pea. By J. J. Taubenhaus. New York, E. P. Dutton & Co. Pp. xx + 232.

In the preface the announcement is made that this book is primarily intended to be a practical treatise for use by both growers of sweet peas and investigators. Those interested in the culture of this plant will no doubt find this book a very useful and helpful guide. It is among the few books which deal with both the culture and diseases of one particular crop. The author's reason for including both phases in the same treatise is naïve in that "the attack of most plant diseases depends on some weak point in the cultural methods which has weakened the host at some phase of its life history."

The first eighty-nine pages are devoted to explicit cultural directions which have been prepared for the author by specialists. The following ninety-five pages are given to a consideration of greenhouse and field troubles, including nine diseases of fungous origin, one of bacterial origin and a brief summary of the several insect pests. Due space is given in the closing chapters, in a clear, concise manner, to methods of prevention and control of these maladies.

The essential facts in the author's several important investigations on the diseases of sweet peas are summarized in this book, yet it is believed that the investigator would prefer to consult the original reports. The grower, himself, can best judge of the author's success in avoiding the use of technical terms. This same difficulty which confronts every teacher of elementary plant pathology has been encountered, and if one were to put himself in the position of the average reader he would find himself at times in a maze of meaningless terms. Certainly the person of less than collegiate training would find himself hopelessly lost if he attempted to wade through certain paragraphs in this book and at such points, one is even disposed to wonder what verbiage the author would have chosen had he purposed to use technical terms.

The binomial *Ascochyta pisi* Lib. was probably employed because it is better known than is the name for the ascigerous stage.

The book is well and amply illustrated, is unusually free from typographical errors and gives the impression of being condensed yet complete. It should have a place in the reference library of plant pathologists and of growers of sweet peas.

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FIELD CONFERENCE OF CEREAL PATHOLOGISTS

The Third Annual Field Conference of Cereal Pathologists of the American Phytopathological Society was held at Madison, Wisconsin, on July 9, 10 and 11. About forty were in attendance at the various meetings. The following program was presented:

MONDAY, JULY 9

The forenoon was spent in visiting the plant pathology laboratories of the University of Wisconsin. In the afternoon, after a discussion by Dr. A. G. Johnson upon "Imperfect Fungi causing Cereal Diseases," the session was continued in the field, where Dr. Johnson's experimental plots were examined. In the evening a supper and smoker were given at the University Club, and in the round-table discussion which followed, the following discussions were given:

1. *Grass rusts and their rôle in cereal conservation;* Leaders, *Dr. J. C. Arthur, Dr. E. C. Stakman.* Dr. Arthur gave a historical dis-

cussion of rust work, with especial reference to his work in preparation of the rust section of the North American flora. Dr. Stakman pointed out five problems in the study of grass rust: (1) Biological specialization; (2) accurate knowledge of distribution of biologic forms in relation to rust epidemics; (3) the rôle of grass rusts in over-wintering uredinia; (4) the rôle of grass rusts in passing epidemics from the barberry to grain; (5) grasses acting as agencies for passing epidemics from one grain field to another.

2. *The relation of the barberry to rust epidemics;* Leaders, *Dr. E. M. Freeman, Dr. E. M. Wilcox.* In the absence of both of the above, Dr. Stakman led the discussion upon this topic also. Mr. Frank Piemeizel, who has charge of the Rust Survey now in progress in the Mississippi Valley, stated that the survey so far had indicated that stem rust overwinters in the extreme South in the uredinial stage, and that the amount of infection upon grain was found to decrease in passing from the south to the north. South of Ames, Iowa, no infection upon barberry was found, but north of that point no infection was found upon grain up to that time, except in the vicinity of affected barberry bushes.

3. *State and Federal legislation against the barberry;* Leaders, *Professor L. H. Bolley, Dr. L. R. Jones.* Professor Bolley reviewed the methods used in securing eradiction of barberry in North Dakota, which is the only state having a law declaring the barberry bush a nuisance. The work of eradicating the barberry bushes in North Dakota has almost been completed. Dr. Jones was unable to be present at the session.

TUESDAY, JULY 10

The forenoon was spent in visiting the farm near Madison operated by the Agronomy Department of the University of Wisconsin. In the afternoon the party went by auto from Madison, Wisconsin, to Watertown, Wisconsin, inspecting various grain fields on the way. In the evening a supper, smoker and round-table was held at the Commercial Hotel at Watertown. The following discussions were given:

1. *State and Federal cooperation in fighting cereal diseases during our food emergency;* Leaders, *Dr. H. B. Humphrey, Dr. F. L. Stevens, Dr. S. G. Kern.* Dr. Humphrey outlined a plan for campaign for eradication of preventable cereal smuts. This work, dependent upon the passage of the Food Bill, is to be done in cooperation with the Extension Service, and is to consist of two phases: first, publicity campaign, by means of the press, posters, etc.; second, men to be sent into the field to cooperate with the Extension Service in securing seed treatment. The subject of community seed treatment plans was also brought up for discussion. Dr. Kern spoke for the need of closer cooperation between the Federal and State Departments, and between states in their work, and of the value in correlating work upon general problems with local ones. Dr. Stevens was not present at the meeting.

2. *Recent investigations on yellow stripe rust; Charles W. Hungerford.* An account was given of work being carried on at Corvallis, Oregon, upon this disease.

WEDNESDAY, JULY 11

The day was spent in Juneau, Wisconsin, Beaverdam, Wisconsin, and on the farm of Mr. Kruger near Beaverdam. Meetings were held at the Court House in Juneau, and at the Mealy Hotel at Beaverdam. These meetings were open for general discussion and transaction of business.

The following business was transacted at the various meetings:

It was voted to have the secretary communicate with the Secretary of the Interstate Cereal Conference to arrange, if possible, to have the next meeting of Cereal Pathologists held at the same place as the Cereal Conference, with one day overlapping for joint meeting.

A committee consisting of Dr. L. R. Jones, Dr. H. B. Humphrey, drew up the following resolution, which was unanimously adopted:

TO THE HONORABLE,
THE SECRETARY OF AGRICULTURE.

We, the plant pathologists representing the chief grain-growing states in conference

assembled, in recognition of the following facts:

1. The national and international need of the maximum production of all food grains for the immediate future.

2. The preventable losses resulting from smuts and other seed-borne diseases.

3. Practical and simple methods of seed treatment known to prevent such losses.

4. The Office of Cereal Investigations has already instigated a movement looking to the more universal treatment of seed for the prevention of these losses.

Resolve: (1) That it is our conviction that this work should be pushed with all possible diligence. (2) That we as representatives of these grain-growing states pledge to this work our hearty cooperation and support.

A committee consisting of Professor H. L. Bolley, Professor M. A. Carleton, and Dr. L. R. Jones, appointed to draft resolutions for the extermination of the barberry bushes, made the following report, which was accepted:

In view of the vital importance of the wheat crop, and as a national emergency measure likely to prove an effective aid in increasing and insuring a better wheat crop in 1918, be it resolved:

That we, the cereal pathologists of the American Phytopathological Society, in summer session assembled at Madison, Wisconsin, respectfully ask the President of the United States to appoint a commission to consider the relation of the barberry to outbreaks of black stem rust of wheat, barley, other cereals and grasses with a view of deciding upon the desirability of eradiction of all cereal rust-bearing strains of the barberry in the United States in order that this source of rust epidemics may be removed.

Be it further resolved that the Secretary be instructed to send a copy of this resolution to the President of the United States.

The following resolutions were also adopted by the Conference:

That the chairman of this body appoint a committee to take up with federal authorities the matter of securing some definite action to insure an adequate supply of fungicides and insecticides, particularly those containing copper, for the protection of important crops against the destruction of fungous diseases and insect pests and to insure a reasonable price for the same such as shall not be prohibitory to their use by the farmers and fruit growers of the United States.

To the Department of Plant Pathology and other Friends and Members of the University of Wisconsin:

Whereas, the cereal pathologists in meeting convened at Madison, Wisconsin, from July 9 to 11, were most hospitably entertained and assisted at their third annual meeting;

Resolved, that we extend our hearty thanks and express our due appreciation for your efforts in our behalf.

The following officers were elected for the ensuing year: Chairman, H. P. Barss. Secretary, C. W. Hungerford.

C. W. Hungerford,
Secretary

SPECIAL ARTICLES

THE POSSIBLE ORIGIN OF THE TOXICITY OF ULTRA-VIOLET LIGHT[1]

It is a general law of photochemical action that only those rays are effective which are absorbed by the system in which the reaction occurs.[2] Visible light-rays are not, as a general rule, selectively absorbed by protoplasm and hence their action is usually confined to specialized pigmented areas which constitute the receptive elements of optical sense-organs. Ultra-violet light, on the contrary, is generally highly toxic, even for colorless organisms, and since this toxicity presumably depends upon and is attributable to photochemical reactions the question presents itself to which constituent of the protoplasm are we to attribute the selective absorption of these rays which is the necessary precedent of their photochemical activity?

It was pointed out nearly forty years ago by Soret[3] that the majority of proteins exhibit a well-marked absorption-band in the ultra-violet spectrum. In seeking for the origin of this absorption-band Soret found that it is especially well exhibited by solutions of tyrosin,

[1] From the department of biochemistry and pharmacology, Rudolph Spreckels Physiological Laboratory, University of California.

[2] Eder, "Handbuch der photographie," Halle, 1884, p. 28.

[3] J. L. Soret, *Arch. d. Sc. phys. et nat. Geneva,* 1878, pp. 322, 359; 1883, pp. 194, 204. A. d'Arsonval, *Arch. de Physiol. Norm et Path. Paris,* 1890, Sér. 5, T. 2, p. 340.

and therefore referred it to the tyrosin radical in the protein molecule. These observations have recently been greatly extended by Kober,[4] who has carried out a spectrographic examination of solutions of the various amino-acids which are the end-results of protein hydrolysis and of certain polypeptids. Kober has confirmed the existence of an absorption-band in the ultra-violet in solutions of tyrosin and also finds that a similar band is exhibited by solutions of phenylalanin. The other amino-acid constituents of the protein molecule exhibit only general (*i. e.*, non-selective) absorption in the ultra-violet spectrum.

The possibility is thus indicated that the tyrosin and phenylalanin radicals of the proteins constitute the optical sensitizers which render living cells susceptible to the toxic action of ultra-violet light. If this were the case then passage of the light through solutions of proteins or the aromatic amino-acids should, by absorption of the toxic rays, to a greater or less extent deprive the light of its toxicity for protoplasm. With this possibility in view the following experiments were undertaken:

Definite volumes of a densely inhabited culture of paramecia were washed by suspending the organisms in tap-water and concentrating them by moderate centrifugalizations until a thick suspension of uninjured organisms in a colorless liquid was obtained. All of the suspensions used were prepared in exactly the same manner and were derived from the same culture.

Our first step was to determine what we have called the "normal extermination period," that is to say the duration of time in seconds of exposure to the direct rays of a Cooper-Hewitt Ultra-violet Light Type Z at a distance of 12 cm. from the quartz tube. For this purpose 0.5 c.c. of paramecium suspension was placed in a flat-bottomed (Syracuse) watch-glass and 0.5 c.c. of tap-water was added. Trials were made with varying times of exposure and the percentage of organisms killed was estimated by counting the individuals of which the cilia had ceased moving. The normal extermination-period was found, under these conditions, to be about 100 seconds. To determine whether the gases formed during the exposure to the ultra-violet light (ozone and nitric-oxide) hastened the killing of the organisms appreciably, a trial was made with a suspension protected from the ultra-violet rays by a thick glass plate, but still exposed to the gases. In this way it was determined that this factor could be overlooked, since after 900 seconds exposure no noticeable effect was observed.

After determining the normal extermination-period with the above procedure, trials were made with similar suspensions in solutios of Witte-peptone, gelatin, amino-acids, etc., the results of 160 such trials being summarized in the table below. Thus a 1 per cent. alanin suspension of paramœcia was prepared by adding 0.5 c.c. of a 2 per cent. solution of alanin to 0.5 c.c. of washed paramecium suspension.

The extermination-periods enumerated in the tables are meant to indicate that *immediately* after the stated period of exposure 100 per cent. of the organisms were dead. For it was found that even after an exposure as brief as 40 seconds in a water-suspension the organisms were affected and ultimately all died.

AVERAGE EXTERMINATION PERIODS

(*Paramecia immersed in Test Solution*)

Water suspension	100	secs.
1 per cent. cane sugar suspension	110	"
1 per cent. urea suspension	110	"
1 per cent. alanin suspension	110	"
1 per cent. leucin suspension	215	"
1 per cent. gelatin suspension	220	"
1 per cent. peptone suspension	300	"

Glutamic acid, amino-benzoic acid and aspartic acid all proved to be themselves toxic for the organisms and could not therefore be tested by this method. Tyrosin is very sparingly soluble in cold neutral water. A saturated solution, although exceedingly dilute, conferred marked protection, the extermination-period being lengthened to 180 seconds. An alkaline solution proved to be toxic and therefore could not be employed in this way.

[4] P. A. Kober, *Journ. Biol. Chem.*, 22 (1915) p. 433.

In order to rule out the possibility that the protective action might be indirect, *i. e.*, not attributable to mere absorption of the toxic rays, and also to permit the employment of toxic acids the following modified procedure was employed:

In a quartz beaker with a diameter of 32 mm. 2 c.c. of the given acid were placed, this amount being just sufficient to completely cover the bottom of the beaker. A square piece of cardboard was placed on the Syracuse dish containing the paramecium suspension. The quartz beaker was then placed over a circular opening in the cardboard, having a diameter of 25 mm. By this means the organisms were shielded from all ultra-violet rays excepting those which passed through the solution in the quartz beaker. In order to fully expose all of the organisms and to standardize the depth of suspension, a paraffine mould was made in the Syracuse dish by holding a No. 3 rubber stopper in the center of the dish and pouring melted paraffine around it. On cooling, the stopper was withdrawn, leaving a depression 20 mm. in diameter in which 0.5 c.c. of paramecium suspension was placed.

Somewhat over 100 exposures were made, using this method with the following results:

AVERAGE EXTERMINATION PERIODS

(*Paramecia not immersed in Test Solution*)

Water	130 secs.
1 per cent. alanin	130 "
1 per cent. glycocoll	130 "
1 per cent. aspartic acid	130 "
1 per cent. glutamic acid	135 "
1 per cent. leucin	250 "
0.5 per cent. tyrosin	420 "
1 per cent. amino benzoic acid	2400 "

It will be noted that the results obtained by this procedure confirm those previously obtained by the method of immersion.

In order to obtain 1 per cent. solutions of tyrosin and cystin, which are very sparingly soluble in water, slight amounts of alkali were added to the test solution in the beaker and the extermination-periods after passage of the rays through alkaline solutions of these acids and of certain of the acids enumerated above were determined, with the following results:

AVERAGE EXTERMINATION PERIODS

(*Paramecia not immersed in Test Solution*)

0.5 per cent. NaOH	150 secs.
1 per cent. NaOH	170 "
1 per cent. glutamic acid in 1 per cent. NaOH	200 "
1 per cent. cystin in 0.5 per cent. NaOH.	1200 "
1 per cent. tyrosin in 0.2 per cent. NaOH	unaffected after 40 minutes exposure.

We may infer that solutions of gelatine, peptone, amino-benzoic acid, cystin, tyrosin and leucin detoxicate ultra-violet rays which pass through them, while solutions of the other substances investigated do not appreciably do so. The protective action of tyrosin in alkaline solutions is exceptionally marked, and in this connection it is of especial interest to note that Kober has found that an alkaline reaction markedly increases the absorption of ultra-violet rays by tyrosin solutions.

The protective action of leucin, which does not exhibit a selective absorption in the ultra-violet, is at first sight somewhat puzzling. It was noticed, however, that both tyrosin and leucin solutions underwent a change of color upon continued exposure to the ultra-violet light. This change was especially marked in the leucin solutions resulting after 40 minutes exposure in closed quartz vessels in the production of a dark brown fluid having a distinctly intensified odor. This solution had a much greater protective power when tested in the above manner than leucin solutions which had not been previously exposed to the light. We may infer that ultra-violet light induces chemical changes in a leucin solution resulting in the production of substances having an enhanced power of absorbing ultra-violet rays.

Our results are therefore decidedly in harmony with the view that the susceptibility of protoplasm to ultra-violet light is conditioned by the selective absorption of the toxic rays by the aromatic amino-acid radicals of the proteins.

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